# The $\eta$ Carinæ 2009.0 "event": a detailed optical photometric record

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IAU XXVII General Assembly
August, 2009 • Rio de Janeiro • Brazil

## Abstract

*During the last "event" ocurred in 2009.0, $\eta$ Carinæ was the target of several observing programs. In our optical photometric monitoring campaign, we recorded with detail the behavior of the associated "eclipse-like" event, which happened fairly on schedule. In this work we present the resulting $UBVRI$ and H$\alpha$ light curves, and a new determination of the present period length.*

## Observations

The 2009.0 event was monitored from two observatories in Argentina: La Plata Observatory (OALP), Buenos Aires, and Complejo Astronómico El Leoncito (CASLEO), San Juan. Observations started in early November 2008, after the annual visibility gap. Our observing program involved the daily acquisition of CCD images. Typically, three or four series of 15 or 20 images each, spanned no longer than 30 minutes each, were obtained for each filter every night.

### Image acquisition from OALP

Observations were performed from November 12, 2008 (JDN 2454782) up to late July 2009, using the 0.8-m "Virpi S. Niemela" (VSN) telescope and a Photometrics-STAR I CCD camera. A standard Johnson-Cousins $BVRI$ filter set was used all the time, and a narrow passband (peak at 656.3 nm, 4.5-nm wide) H$\alpha$ filter was incorporated to the monitoring on December 26, 2008 (JDN 2454827).

### Image acquisition from CASLEO

CCD image acquisition was performed during November 27-29, 2008, December 17-23, 2008, and January 07 to February 03, 2009, using a Photometrics CH250 CCD camera attached to the 0.6 m Helen Sawyer Hogg telescope (f/15 Cassegrain) at CASLEO. The images were taken using a standard Johnson-Cousins $UBV$ filter set.

### Data reduction

The data reduction process was exactly the same as the one detailed in Fernández-Lajús et al. (2009), HDE 303308 ($V$=8.15) being the comparison star for the $\eta$ Car relative photometry. The aperture radius for extracting the instrumental magnitudes in the $U, B, V, R$, and $I$ bands was again 12″, enclosing the complete Homunculus. For the H$\alpha$ photometry, a rather small aperture radius = 3″ was used to get a higher signal-to-noise relation for the comparison star, taking into account that this object is more than 6 magnitudes fainter than $\eta$ Car in this band. The averaged errors of our differential photometry from OALP are: $\epsilon_B = \pm 0.008$, $\epsilon_V = \pm 0.005$, $\epsilon_R = \pm 0.009$, $\epsilon_I = \pm 0.013$, and $\epsilon_{\mathrm{H}\alpha} = \pm 0.012$ mag; and those from CASLEO are: $\epsilon_U = \pm 0.005$, $\epsilon_B = \pm 0.008$, and $\epsilon_V = \pm 0.015$ mag.

## Results

The resulting $UBVRI$ and H$\alpha$ light curves of the 2009.0 "eclipse-like" event are depicted in Fig. 1. The $UBVRI$ zeropoints were extracted from the HDE 303308 photometry provided by Feinstein (1982). No zeropoint was applied to the H$\alpha$ data. All the light curves are folded using cubic splines. They are featured by an ascending branch starting at about JDN 2454816 and lasting almost 30 days, when a maximum is reached. This maximum peaks at different dates depending on the photometric band and is followed by a steep fading towards the minimum. In the $R$ band the lack of the first ascending branch produces no maximum, with the exception of a sharp peak centered at JDN 2454834. Although the $U$ light curve is not complete, the general behaviour is evident. Unfortunately, the H$\alpha$ line photometry was not recorded during the event before JDN 2454827 when the maximum apparently occurred. After the minimum, a second ascending branch develops until almost the same brightness reached at maximum is recovered. The H$\alpha$ light curve shows a less pronounced rising tilt. Figure 2 depicts the complete light curves through "cycle 11", including 2003.5 and 2009.0 events. The present status of the visual band in a historical context, is shown in Figure 3.

**Daily updated light curves are available at http://etacar.fcaglp.unlp.edu.ar/**

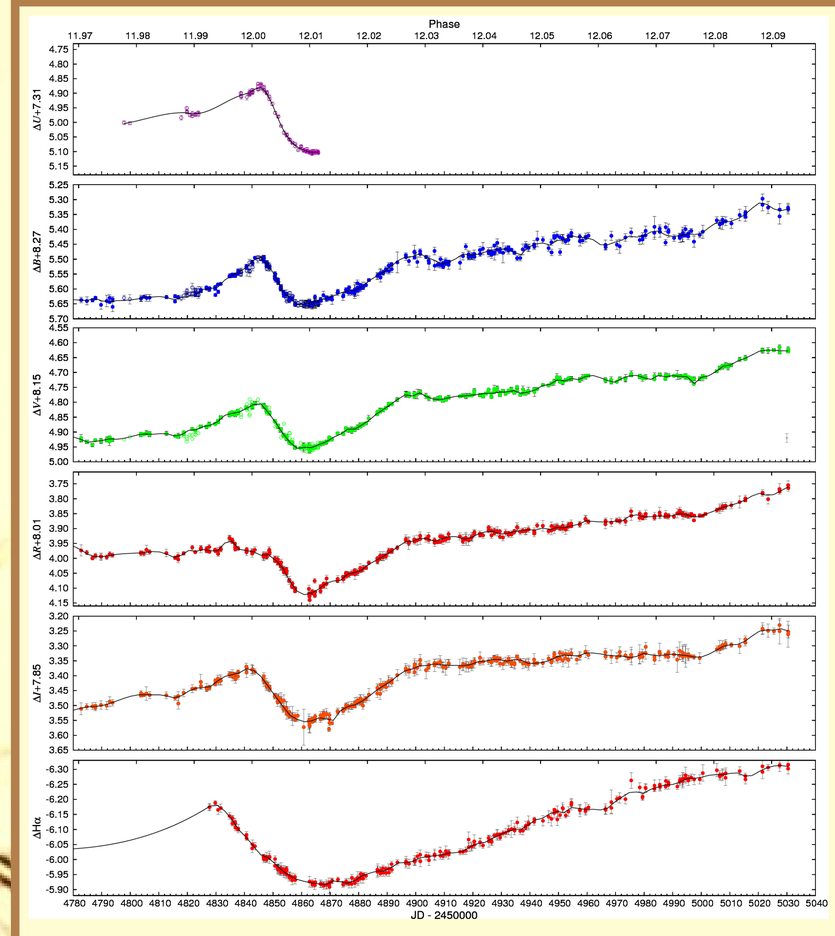


**Figure 1.** The $UBVRI$H$\alpha$ light curves of the 2009.0 event.

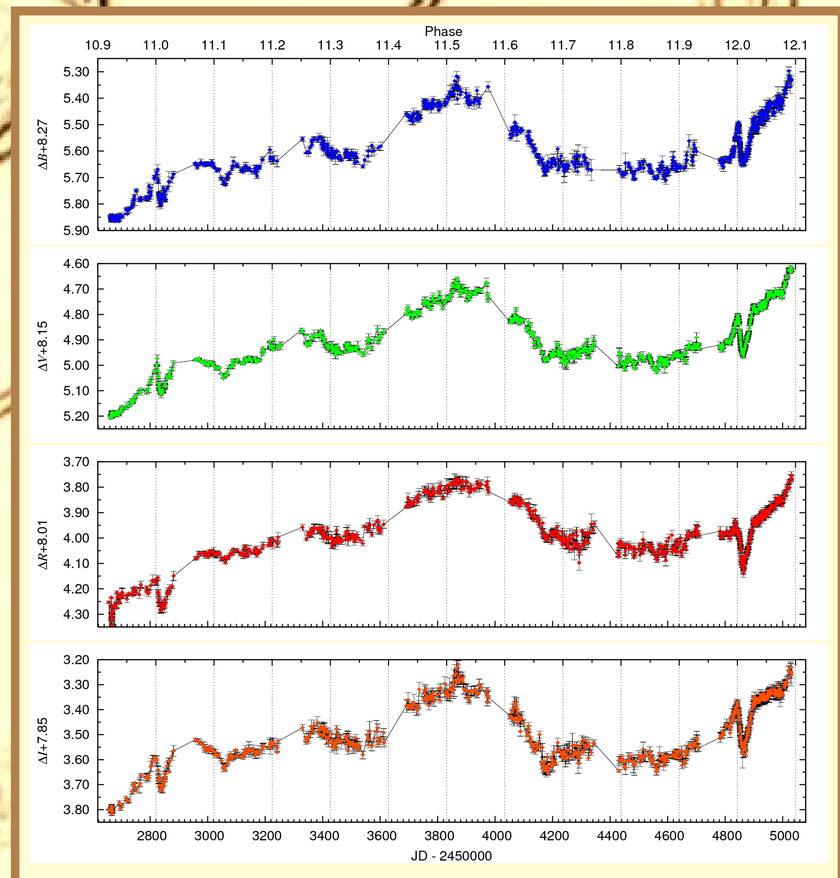


**Figure 2.** $BVRI$ light curves of $\eta$ Car acquired at La Plata, from 2003 to 2009. The light curves pass through the complete "cycle 11".

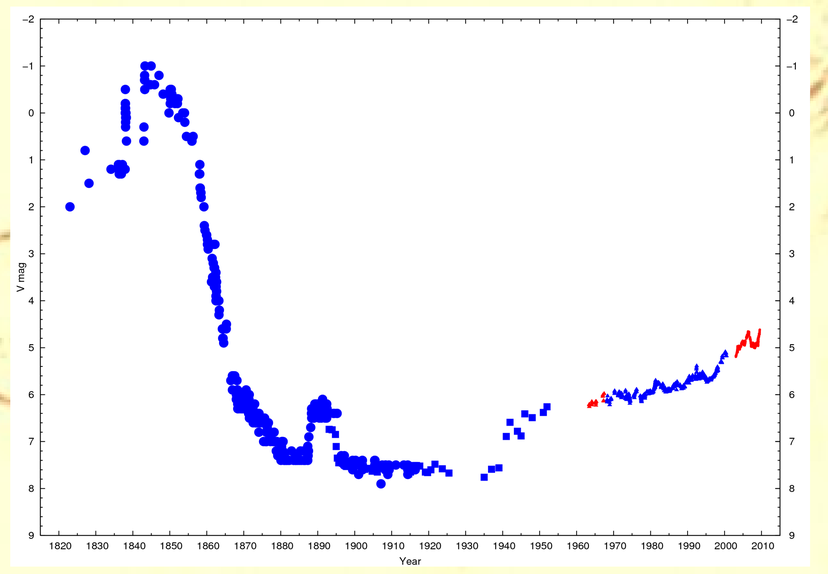


**Figure 3.** Visual light curve of $\eta$ Car from 1820 to 2009, based on the references given by Fernández Lajús et al. (2009) and the data from this work. Red points are observations made from La Plata (Feinstein 1967; this work).

## Period fitting

A new estimation of the period lenght was made using our $BVRI$ photometric data of the 2003.5 and 2009.0 events, and the "phase dispersion minimization" method (Stellingwerf, 1978). We obtained that the most significant period values, common to all photometric bands, span between 2021.9 and 2023.5 days. From a final visual inspection, we adopt for the period length of "cycle 11": P = $2022.8 \pm 0.5$ days. If we consider the date of $\phi = 0$ given by Damineli et al. (2008), the orbital phase can be calculated using the following ephemeris:

$$JD(\phi = 0) = 2452819.8 + 2022^{\mathrm{d}}.8 \cdot E \qquad (1)$$

## Remarks

The 2009.0 event optical photometric behaviour happened very close to the dates announced by Ferández Lajús et al. 2009. In the optical range the event exhibited once again an "eclipse-like" light curve. It was evident in all the $UBVRI$ bands and also in the narrow H$\alpha$ band. In spite of this overall similar behaviour, the time of occurrence of some features and other photometric details (for instance the depth of the dips) differ in each band, especially in $R$ and H$\alpha$.

All these features resemble the behaviour registered during the 2003.5 event. The main difference is that the 2009.0 minimum is about 0.02-0.03 mag deeper than the previous one, and the recovering branch is also steeper.

The starting of the minimum registered in the $V$ band takes place 15 days after the phase of minimum excitation (Damineli et al., 2009) and 11 days after the starting of the minimum in X-rays (Corcoran, 2009). This is in good agreement with what happened in the 2003.5 event.

The new estimation of the current period length is in complete agreement with the average value derived by Damineli et al. (2008) from different spectral features and photometric bands.

The periodic recurrence of the observed events is verified by the fact that this 2009.0 event occurred at the time predicted some time ago. This periodicity and the "eclipse-like" feature displayed in the optical light curves strongly support the proposal of the binarity of $\eta$ Car.

**Image 1.** Colour composite image of the $\eta$ Car's field (1'54" x 2'50"), obtained from 3 of our $B, V$ y $R$ images taken from OALP. Comparison and check stars are identified:
1- $\eta$ Carinæ
2- HDE 303308
3- CPD-59 2628
4- CPD-59 2627

## Acknowledgements

The authors acknowledge the authorities of the FCAG-UNLP and CASLEO for the use of their observational facilities. We warmly thank the technical staffs of both observatories for the maintenance of and improvements to the telescopes and their equipments. We acknowledge the participation of M. Haucke during the observations.

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